6. What is a symmetry transformation?

7. Write an express for expectation value of an observable using density matrices.

8. Define parity.

9. Write the value of commutators

   (a) $[J_x, J_y]$ and

   (b) $[J^2, J_2]$.

10. State Wigner-Eckart theorem.

SECTION B — ($5 \times 5 = 25$ marks)

Answer ALL questions.

11. (a) What are stationary states? Show that the probability current density is constant in time in stationary states.

Or

(b) Discuss the problem of 1-D tunneling.

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12. (a) Show that the Hamiltonian must be Hermitian for conservation of probability.

Or

(b) Show that the operator associated with the vector r in the momentum representation is $i\hbar\nabla p$.

13. (a) Discuss the Heisenberg picture.

Or

(b) Explain conservation laws.

14. (a) What are density matrices? Discuss is properties.

Or

(b) Explain why time reversal operator is not linear.

15. (a) Obtain the matrices for the operators J_+ and J_- for $j = 3/2$.

Or

(b) Compute

   (i) $[L_x, L_y]$

   (ii) $[J_+, J_-]$.

SECTION C — (3 × 10 = 30 marks)

Answer any THREE questions.

16. Find the transmission probability for a particle incident on a one-dimensional potential barrier of height V_0 and width a. Consider the two cases when

(a) the energy of the particle is $E > V_0$ and

(b) $E < V_0$

17. Explain the postulates of quantum mechanics.

18. Obtain the solution for simple harmonic oscillator by the operator method.

19. Explain Reduced density matrix. Explain its importance with an example.

20. Obtain the Clebsh-Gordan coefficients for a system having $j_1 = 1$ and $j_2 = 1/2$.

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APRIL/MAY 2025

GPH13/DPH13 — QUANTUM MECHANICS – I

Time : Three hours Maximum : 75 marks

SECTION A — (10 × 2 = 20 marks)

Answer ALL questions.

1. Write down the equation of continuity.

2. Give the condition for a wave function to be normalized.

3. Show that $p_x = -i\hbar \frac{d}{dx}$ is a Hermitian operator.

4. State Ehrenfest theorem.

5. Show that for any operator which commutes with the Hamiltonian, the operators in the Schrodinger and Heisenberg pictures are identical.